Forest resources variation along with the main rivers in typical forest region of Changbai Mountain

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Abstract: The restoration of the riparian vegetation disturbed by human activities is one of the hotspots of watershed ecology. Through interpreting the images of Remote Sensing in 1985 and 1999, the basic information of forest resources of Lushuihe Forest Bureau, which is a typical forest area of Changbai Mountain, was obtained with support of GIS. By dividing Land covers of Lushuihe area into 10 types (water body, residential land, stump land, farming land, wetland, mature conifer forest, midlife conifer forest, mature broadleaf forest, midlife broadleaf forest, and man-made young forest) and dividing the riparian zone into four buffers (in turn, 1000, 2000, 3000, 4000 m away from the river), the changes of riparian forest resources during 1985-1999 were analyzed. The results showed that the deforestation intension has obviously decreased and the whole environment has been evidently improved, but the riparian ecosystem was still flimsy. In buffer 1, 2, 3, the area of midlife conifer forest increased largely, but the areas of other types of land covers all decreased. Midlife conifer forest had a comparatively good status in the three buffers. In buffer 4, midlife conifer forest, mature conifer forest, and mature broadleaf forest formed a forest-age rank that is helpful to stabilize the forest ecosystem and exert its functions. Area percentage of wetland decreased in buffer 1, buffer 2, and buffer 3, even in buffer 4 in which forest ecosystem rehabilitated comparatively well, so protecting and rehabilitating wetland is a very difficult task.

Key words: Forest resources; Buffer; Riparian belt; Remote sensing; GIS
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Introduction

Riparian belt lying both sides of the river takes on a long and narrow shape generally. The river obstructs energy and substance from the neighboring ecosystems. The border of riparian belt only is a transitional belt and has no obvious borderline. Aside from microclimate, the age and continuity of the riparian vegetation are the factors affecting its formation. Transform types of substance stream and information stream are different within different distances to the river. Forests, as an important part of the riparian belt, have important ecological, aesthetic and social-economic functions in the whole riparian ecosystem (Chen 1996, Cuervo 1998). Frequent human activities usually bring about damages to the riparian belt and vegetation. The subversive results, which may come out after a period of time and space delay, can weaken the function of riparian ecosystem in defending against flood, debase water quality and deteriorate the whole riparian habitat etc. (Gregory 1996; Pllock 1998; Deng 1998). Protecting forest resources on both sides of the river, resuming and rebuilding riparian belt forest demolished by human being are the basis of watershed ecological safety. Buffer within the riparian belt in Europe and America is a general concept (Cai 1997); forests belong to one part of riparian belt. The core of discussing conditions of forest resources in the riparian belt is to reasonably mange forest. The management objects of vegetation in the riparian belt are to protect resources and riparian ecosystem and provide condign habitat conditions for the vicinal plants and animals (Green 1998). Past researches on riparian belt mainly focused on single function such as amusement (Brown 1991; Carson 1993; Doubert 1981; Duffield 1992), few researches dealt with forest ecosystem in the riparian belt. River has close relationship with human being and is attributively stable in many years, so carrying research on forest resources type and changes within some distance from the river are helpful to protect forest resources.

Study area and methods

Study area

The study was conducted at Lushuihe Forest Bureau (127°29′-128°02′ E, 42°20′-42°40′ N), which is located in the northwest area of Changbai Mountains at the average altitude of 600-800 m. This area has temperate continental climate, characterized by a cold weather during the long winter and short cool summer. Low temperature, humidity and low evaporation are helpful to form exuberant broadleaf-conifer forests; broadleaved/Korean pine forest is

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the zonal vegetation in the area. Forest in the region has obvious and complex layers, high canopy density, and complex structures. Lushuihe Forest Bureau is divided into eight forest centers and mainly undertakes the task of wood production. Before the 1980s, a large area of clear cutting was the main type of deforestation. Because of unconscionable forest policies, forest resources were seriously destroyed. Since the middle of 1980s, Lushuihe Forest Bureau has adopted scientific and diverse forest polices and achieved many achievements. Water system of the region mainly consists of Lushui River, Xilin River, Xiangshui River, Qingshui River, Sandaozi River, Sidaozi, Wudaozi River. These rivers, with abundant amount of water, are one of the important water resources of Songhua River. The general conditions of these rivers are shown in Table 1.

Table 1. General condition of the primary rivers in the region

Name of river	Length (km)	Average width(m)	Average depth (m)	Volume (m^3/s)	Velocity of flow (m/s)	Term during flood (Month)
Lushui	61.1	20	5	11	1	Aug.-Sep.
Xilin	29.9	10	5	6.1	1.12	Aug.-Sep.
Qingshui	41.2	15	5	7.7	1	Aug.-Sep.
Xiangshui	8.0	8	4	3.5	1.35	Aug.-Sep.
Sandaozi	31.3	10	4	4.5	1.2	Aug.-Sep.
Sidaozi	14.7	10	4	4.5	1.3	Aug.-Sep.
Wudaozi	11.2	9	4	3.7	1.4	Aug.-Sep.

Methods

The remote sensing (RS) images obtained in 1985 and 1999 were interpreted to get the basic information of forest resources. In order to improve classification precision of RS image, it was necessary to have detailed ground Global Position System (GPS) investigation, know about features of forest resources, and refer to production practices and research results about the region. Land covers of Lushuihe area were divided into 10 types: water body, residential land, stump land, farming land, wetland, mature conifer forest, midlife conifer forest, mature broadleaf forest, midlife broadleaf forest, and man-made young forest. These types of land covers were described as Table 2.

After the processes of Data Preparation, Geometric Correction, Tasseled Cap, Supervised Classification, Evaluation Classification and Post-Classification Process, the picture including each type of forest resources was mapped. Practical investigation showed that the patches caused by human activities had the characters of distributing along with both sides of the river and its extension from one side is generally less than 5 000 m. Thus, the riparian zone was divided into four buffers, named buffer1, buffer 2, buffer 3, buffer 4 in turn, 1 000, 2 000, 3 000, 4 000 m away from the river.

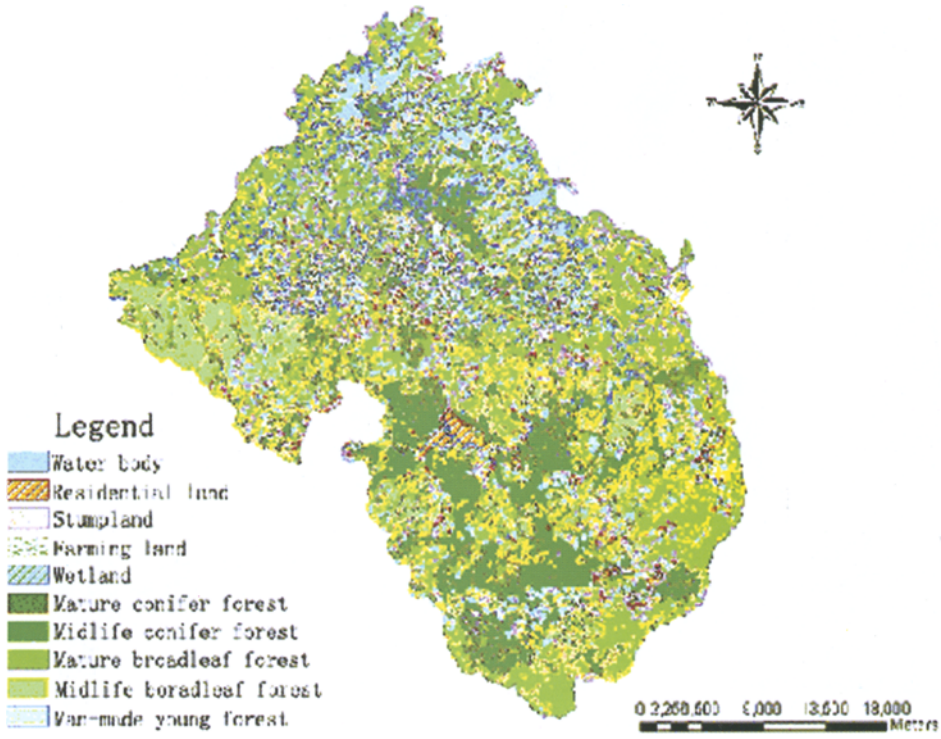
Table 2. Description of classification system of RS image procession for the study area

Type of land coves	Description
Water	Including rivers, reservoirs and pools etc.
Residential land	Including residence, industrial and commercial facilities, and roads etc.
Stump land	After deforestation, nearly naked land covers. Having obvious patch features in the RS image, and mainly consisting of shrub and weed etc.
Farming land	Cropland, vegetable land etc for agriculture use.
Wetland	Spectral features between water body and other land covers.
Mature conifer forest	Large areas of nearly mature, mature and over mature conifer forests, mainly consisting of *Pinus koraiensis*, *Picea mongolica*, *Abies faxoniana*, *Abies holophylla* Maxim, etc.
Midlife conifer forest	Developing forests mainly consisting of *Pinus koraiensis*, *Picea mongolica Abies faxoniana*,*Abies holophylla* Maxim
Mature broadleaf forest	Large areas of nearly mature, mature and over mature broadleaf forests, mainly consisting of *Franxinus mandshurica*, , *Quercus mongolica* Fisch, *Popular davidiana+Betula platyphylla* etc.
Midlife broadleaf forest	Developing broadleaf forests consisting of many species of broadleaf trees and with wide spectral width in the RS image.
Man-made broadleaf forest	Planted on the large areas of stump land, having particular feature in the RS image.

Results and analysis

Classification results of RS image and buffer division

Classification results and buffer division of forest resources in 1985, 1999 are illustrated as Fig.1, 2 respectively. The four buffers were named buffer1, buffer 2, buffer 3, buffer 4 in turn, 1 000, 2 000, 3 000, 4 000 m away from the rive respectively. After Spatial Overlay, Feature Extraction, transforming raster data to vector format, attributive data of forest resources were formed, which were used to analyze the changes forest resources in different buffers.


Legend
Water body
Residential land
Stumpland
Farming land
Wetland
Mature conifer forest
Midlife conifer forest
Mature broadleaf forest
Midlife broadleaf forest
Man-made young forest
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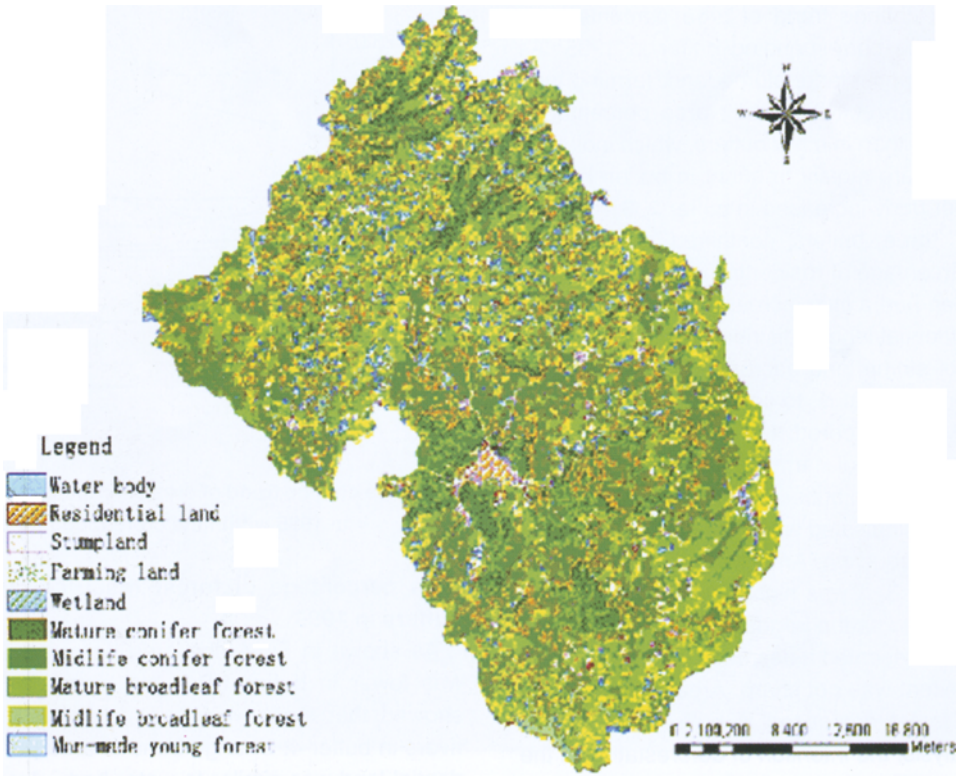
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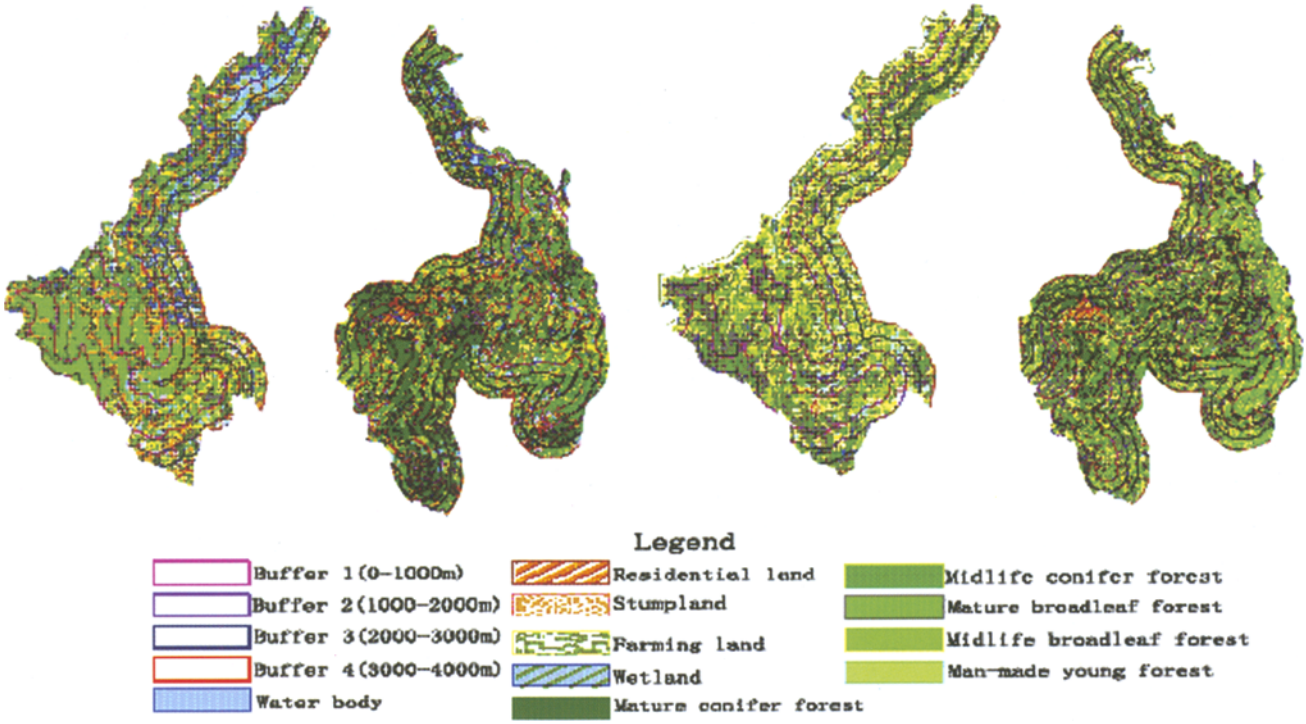

Fig. 2 Buffer divisions of forest resources (left, 1985; right, 1999) in the study area

Area percentage of forest resources within the four buffers in 1985

Fig. 3 shows the change trend of area percentage of forest resources in the corresponding buffer in 1985. As shown in Fig. 3, residential land, stump land, farming land as the output of human activities, their area percentages were higher in buffer 1 than in other buffers, which indicated that human activities are mostly frequent in buffer 1. Area percentage of water body increased in buffer 2, 3, 4, which showed that the three buffers contained many water branches. Area percentage of residential land decreased in buffer 2, 3, and then had a little increase in buffer 4, which illustrated that residential land is distributed near the rivers. Area percentage of stump land decreased in buffer 2, but increased in buffer 3, 4, that is, to some extent conserving water resources was considered during designing logging region. Area percentage of farming land decreased in buffer 2, 3 then increased in buffer 4, but its area in buffer 1 was the largest, which indicated water was important to the regional agriculture production. Area percentage of mature conifer forest in buffer 3, 4 was higher than in buffer 1, 2, and its area in buffer 4 was the largest. Area percentage of midlife conifer forest presented a decrease trend in buffer 2, 3, 4, but change extent was not sharp. Area percentage of mature broadleaf forest decreased in buffer 2, 3, 4. According above analysis, the intention of deforestation in the four buffers before 1980 was high, and only few patches of mature forests were remained.

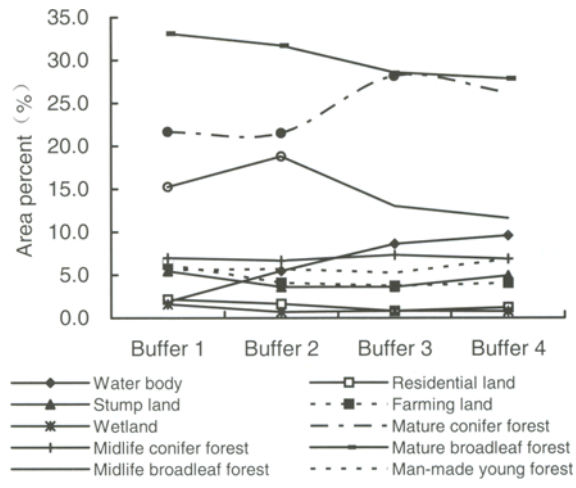

Fig. 3 The change trend of area percentage of forest resources in 1985 within the corresponding buffer

Area percentage of forest resources within the four buffers in 1999

As shown in Fig.4, the area percentage of water body was lower in buffer 1,2,3, but higher in buffer 4, which showed that there were relatively abundant branches of rivers in buffer 4. Change trend of area percentage of residential land was similar to water body. Area percentage of stump land in the corresponding buffer was low, that indicated most remained stump had been planted. The farming

farming land and wetland in the buffers had little change. Area percentage of mature conifer forest in buffer 1, 2, 3, 4 increased successively; it had higher area percentage than some other types of land covers. The change trend of midlife conifer forest was contrary to mature conifer forest; the main reason was that many midlife conifer forests transferred to mature conifer forest during the fifteen years. Mature broadleaf forest had higher area percentage in the corresponding buffer, and its area percentage decreased in buffer 1, 2, 3 successively, but had an increase in buffer 4. Chang trend of midlife broadleaf forest was contrary to mature broadleaf forest; the main reason was that many midlife broadleaf forests transferred to mature broadleaf forest and many nature broadleaf forests in buffer 4 were cut during the fifteen years. Area percentage of man-made young forest increased in buffer 1, 2, 3, and 4 successively.

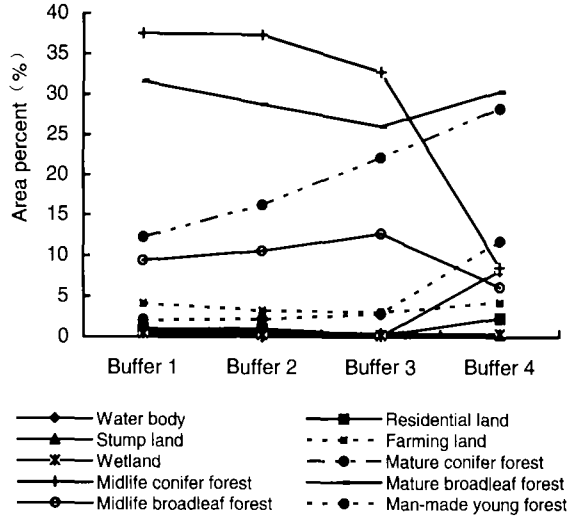

Fig.4 The change trend of area percentage of forest resources in 1999 within the corresponding buffer

Contrast analysis of area of forest resources in 1985 and 1999

Fig.5 showed the change in area of forest resources in the corresponding buffer during the fifteen years

In buffer 1, area of midlife conifer forest increased sharply, but the area of mature conifer forest, midlife conifer forest, stump land, man-made young forest, farming land, mature broadleaf forest, wetland, residential land, and water body decreased successively. In buffer 2, the area of midlife conifer forest increased sharply, but area of other types of land covers decreased successively.

In buffer 3, the area of midlife conifer forest increased sharply, but the area of water body, mature broadleaf forest, stump land, mature broadleaf forest, man-made young forest, farming land, residential land, and midlife broadleaf forest decreased successively.

In buffer 4, the area of midlife broadleaf forest, stump land, water body, and wetland decreased successively; area of farming land, residential land, midlife conifer forest, mature conifer forest, and mature broadleaf forest increased successively. Midlife conifer forest, mature conifer forest and mature broadleaf forest formed an age-class echelon, which is helpful to promote stabilization and functions of forest ecosystem. Human disturbance to forest ecosystem in buffer 4 was relatively lower than in other buffers during the fifteen years.

In buffer 1, 2, 3, area increment of midlife conifer forest was higher than other types of forests in the corresponding buffer, so it had rehabilitated relatively. In the four buffers, the area of Stump land decreased sharply, at the same time, area of man-made young forest also decreased in buffer 1, 2, 3, which revealed that until 1999 deforestation in the buffers had decreased. Area of wetland presented a decrease trend in the four buffers. Much attention should be paid to the protection of wetland.

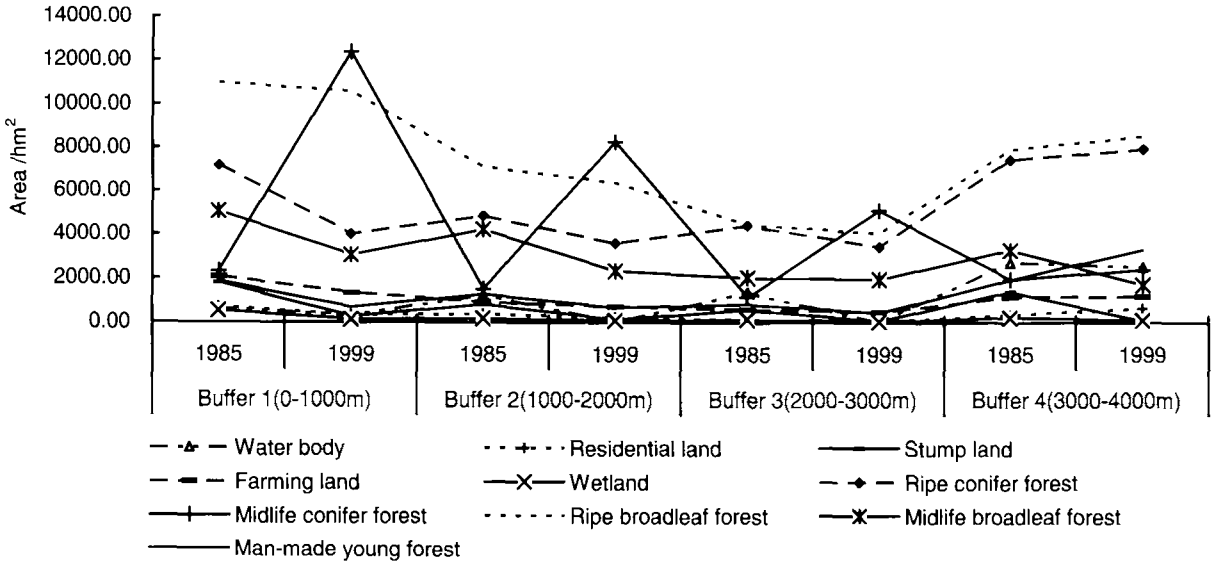

Fig. 5 The change of forest resources in area in the corresponding buffer in the fifteen years (1985-1999)

Conclusions and suggestion

Human disturbance to forest resources was heavier before 1985. According to vegetation composition of riparian belt, broadleaved and Korean pine forest had very little area percentage; the whole ecosystem balance had already been disturbed. Vegetation in most areas has entered into a succession process affected by human activities, but part process was adverse succession such as wetland was reclaimed into farming land. To one's enjoyment, after 1985, the forest policies were improved and some forests to a large extent refreshed when people increasingly recognized more multiple functions of forest. But in the whole, forest ecosystem of the riparian belt were still frail and must be elaborately protected and managed.

Xu Huacheng (Xu 1996) once had pointed out that two methods could be adopted to manage and protect riparian forest ecosystem. The one, main crop should not be carried out in protection belt of the river, the other, crop intensity should be strictly restricted and sometime, the two methods should be incorporated with each other. Whether what methods are adopted, considering ecological function of forest is the most important point. Furthermore, division interval of buffer for riparian vegetation is an important aspect. Many factors such as soil conditions, vegetation type, land use etc., especially human effect should be taken into account so as to objectively reflect the facts in the study site.

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